COURSE TITLE: ELECTRICAL SYSTEM COMPONENTS

Lesson IV: SURGE PROTECTION

It is well known that surge voltage in a power system is caused due to 2 reasons

i) Internal overvoltage

ii) External overvoltage condition

I.1- Internal Overvoltage

Stationary overvoltage may occur due to prolonged single phase to ground fault, with the neutral is either grounded through a arc suppression coil. It may also happen due to current chopping.

I.2- External Overvoltage

Due to atmospheric discharge through static charge or lightening strokes this type of overvoltage may occur.

To protect the switch gear and protection system from this condition, some special precaution may be taken. Before discussing about the schemes of protection, it is important to understand the concept of surge first.

I.2.1 The Concept of Surge

When a lightening surge or internal overvoltage condition strikes the end point of a transmission line it releases charge on the line and depending upon the inductance of the transmission line a voltage wave that is proportional to the charge density and a current wave travel over the line. Depending upon the L and C values of the line, the shape of the wave front of the voltage wave will be decided. So, more the L value, a steeper wave front will be available. The value of C of the line to ground impedance of the line, several bushings, insulators etc., decide the shape of the wave front. Moreover, when such an wave front strikes an open ended line, then the reflective wave front shall double up depending upon the amount of charge in the surge impedance.

To protect such surges, two stages of defense is provided. They are discussed below

a) Earthing Screens

This is the first line of defense provided, and they are like ground wires, sheets, provided over transmission line, substation buses, and other switchgears particularly those located outdoors. They can be copper conductors connected to ground.

b) Surge Diverters or Arrestors

The surge diverters better known as arrestors basically safe guards the insulation of the terminal apparatus and it ceases to carry current after a discharge.

c) Surge Modifiers

Surge capacitors and air cooled surge reactors modify the steepness of the wave front.

d) Surge Absorbers

Inductor metal shields absorb low energy surges. This device is appropriate for short duration surges as it can reduce only the steepness of the wave front. Such devices are not cost effective for higher transient surges.

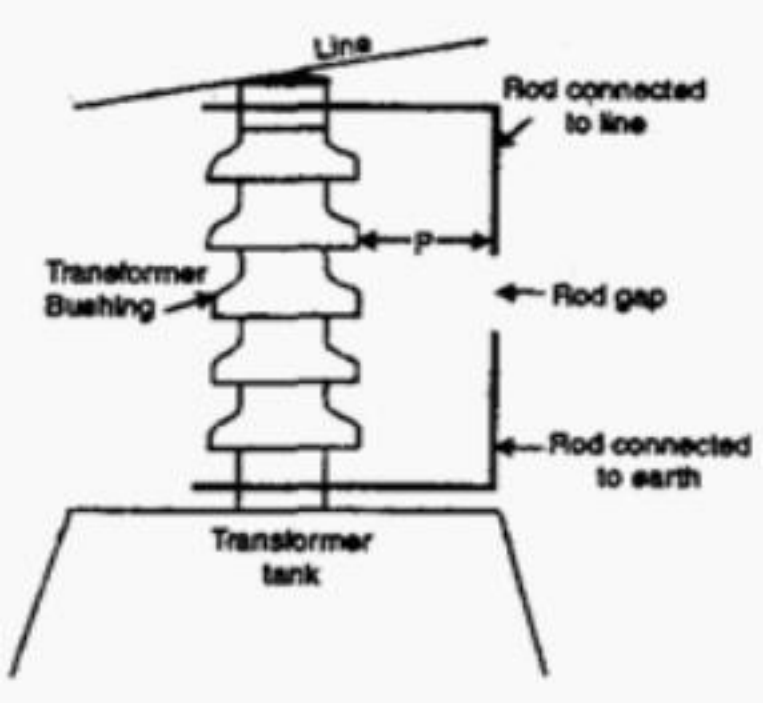
II. Lightning Arrester

Out of the different protective equipments, Lightening Arresters (LA) are more widely used.

They are of different types as follows

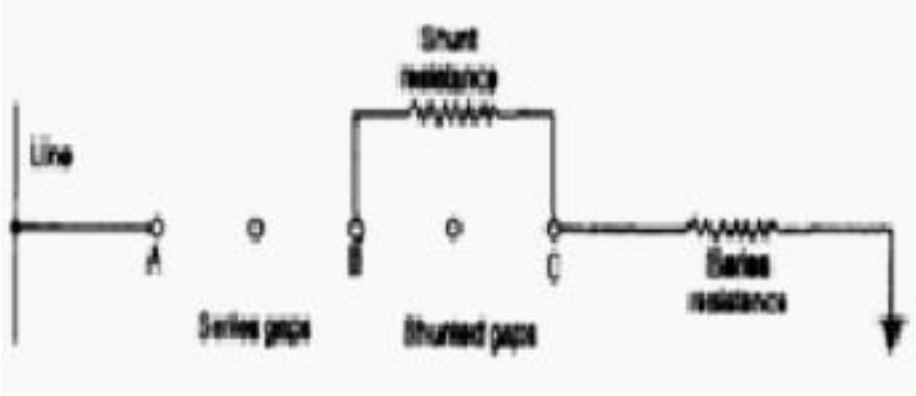
a) Rod Gap Arrester

This type of arrester is for lower voltage application. When the surge exceeds the designed value of the gap an arc is initiated. A small square rod of size 1 cm bent at right angles and connected between the line and earth as shown in the figure above. The distance between the rod and the insulator should not be less than the gap length so that the arc could reach the insulator and damage it. When the surge voltage reaches the design value of the gap an arc appears in the gap providing an ionized path between it and ground.



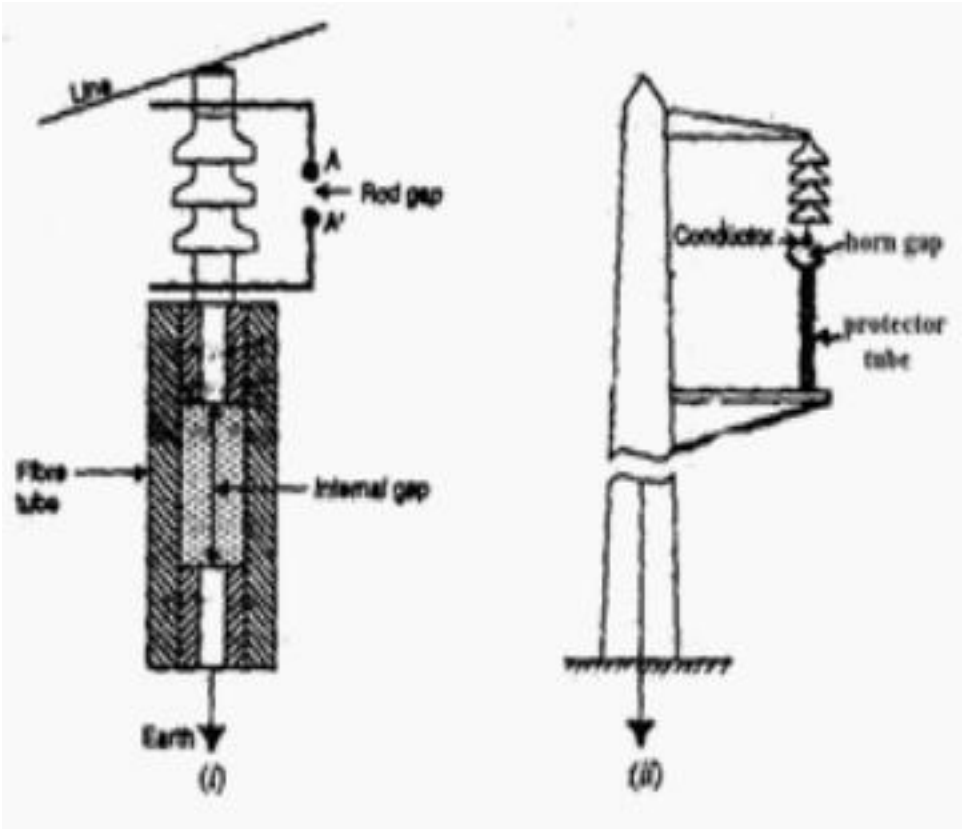
b) Horn Gap Arrestor

It consists of horn shape metal rods separated by a small air gap. The horns are so constructed that the gap between them gradually increases towards the top as depicted in the figure below. The horns are mounted on insulators. One of the horns is connected to the line through a resistance R and a choke coil L. The other end of the horn is solidly grounded. The resistance helps in limiting the current flow to a small value. The choke coil is so designed that it offers small reactance to the power frequency but a high reactance during transient frequency. Thus it does not allow the transient to enter into the apparatus to be protected. The gap between the horns are so designed that the normal power frequency supply voltage is not sufficient to cause a spark across gaps.



c) Multi gap arrestor

In this type of arrester, metallic cylinders of metal alloys of zinc, insulated from each other and separated by small multiple intervals of air gaps are connected in series as shown above. The first cylinder A in series is connected to the line and the others B and C to the ground through a series resistance. The series resistance limits the power loss to the arc. The two cylinders B and C are also shunted through resistance. Under normal conditions, the mid cylinder B is at earth potential and the normal supply voltage is unable to break down the series gap. During, a transient overvoltage condition the first two series gaps break down first. Out of the two gaps between the three cylinders, the second gap is there for extra safety.



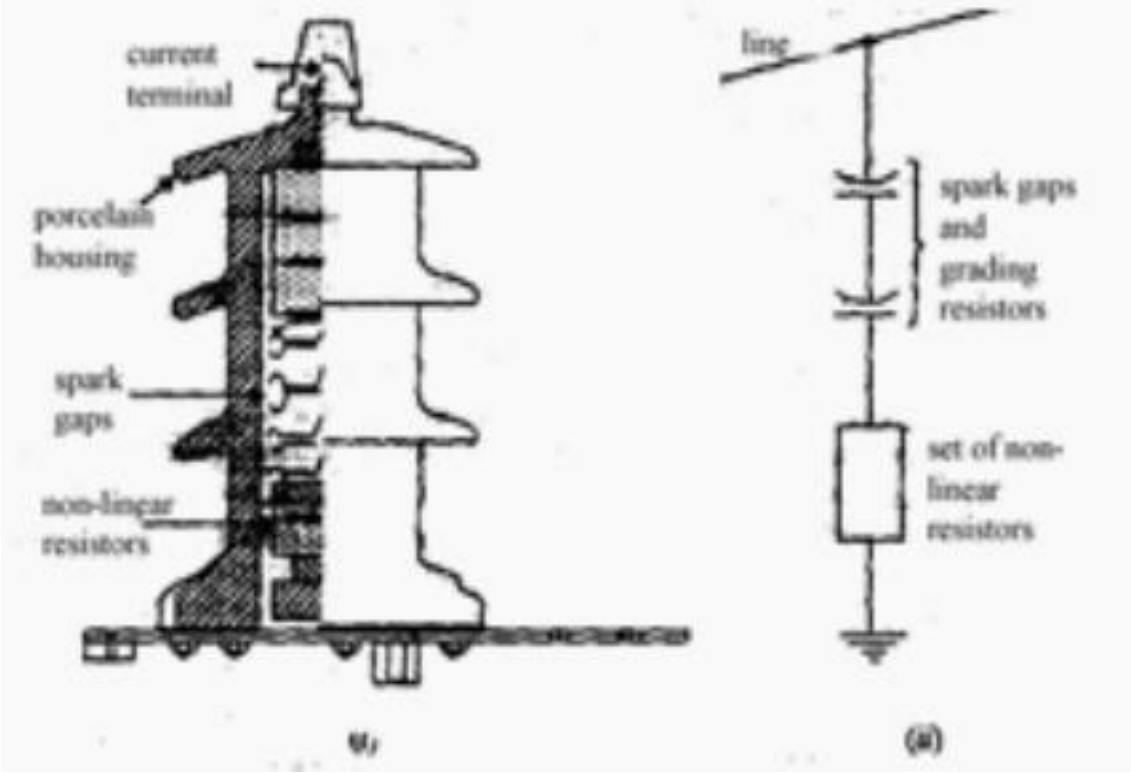
d) Expulsion type arrestor

This type of arrestor is also known as the protector tube, which is commonly used on systems operating at voltages upto 33 KV. As shown in the figure above, this type of arrestor has two gaps. One of them is a normal rod gap and the other one is enclosed within a fiber tube. The second gap has two electrodes inside the fibre tube. The upper electrode is connected to the rod gap and the lower electrode to the earth. The entire expulsion tube is hung from a transmission line with the help of insulators. The series gap is set to arc over a specified voltage lower than the withstand capacity of the line or the equipment where it is mounted. This tube does not have long life and therefore not used these days.

e) Valve Type arrester

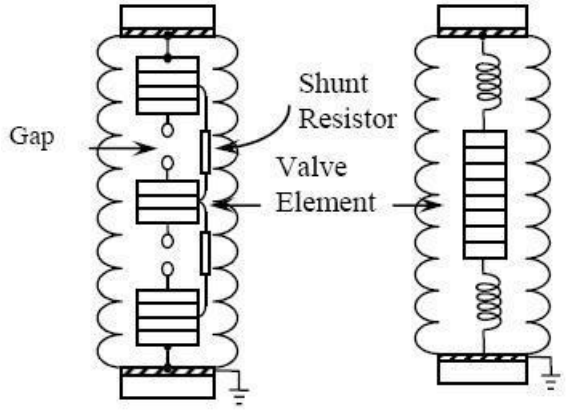
This type of arrestor has a non linear resistor in series with the spark gap as shown below. In traditional arresters, the characteristic of the gap spark over voltage versus the surge front time does not match well with the strength versus front characteristics of most of the insulators. Thus it is difficult to coordinate the protective device with the system voltage for which it is used. To resolve this non linear resistors are used in series with the gap to limit the power follow current after an arrester discharge

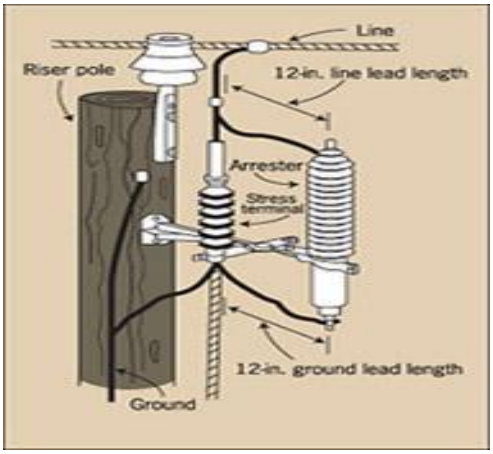
operation. These arresters are used for higher voltage application. Both the assemblies of spark gap and non linear resistor are housed inside a tight porcelain container. There are two types of such arresters and they are discussed below.



f) Silicon Carbide Lightening Arrester

A non linear Silicon Carbide (SiC) material is connected in series with the spark gaps as shown below. The spark gaps provide high impedance during normal condition, where as the SiC disks restricts the flow of current through the spark gap. The non linear resistor of SiC is made by mixing the same by binding material and forming a moulded disk. The disk diameter depends on its energy rating and thickness on the operating voltage rating. The V-I characteristics of a SiC has a hysteresis type loop, the resistance being high during the rising part of the impulse wave and it has a lower value during the tail of the wave front. These type of arresters are used upto a voltage level of 220 KV.





Metal Oxide Lightening Arrester: The Metal Oxide (MO) arrester shown below, uses metal oxide varistors for manufacturing. The main component being ZnO powder, mixed with some other metal oxides to form a ceramic mould. The characteristic is robust enough to avoid any use of spark gaps in series. Due to higher levels of leakage current compared to SiC type of arresters during transient overvoltage conditions. However, they carry even lesser current during normal voltage condition, therefore, they have even more non linear characteristics so that spark gaps can be avoided unlike the SiC type of arresters. During surge expulsion when the surge current is very high in the range of 250-500 A, a shunt gap provided in series with the arrester safeguards by bypassing with a spark over. These types of arresters are used for even more voltage levels.